A TYPHOID CARRIER ON SHIPBOARD

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An investigation just completed by the California State Board of Health has traced twenty-seven cases of typhoid among sailors to a carrier in the crew of a lumber steamer. Four of the patients succumbed to the disease. This typhoid carrier is unique among those already reported inasmuch as he was a member of a ship's crew and infected a large number of his companions without having anything to do with the handling of their food. The danger from typhoid on this ship was so well known among sailors that the vessel was called the "fever ship" and it was difficult to secure desirable men for the crew.

For three and a half years it has been noticed at the United States Marine Hospital in San Francisco that a large part of all the typhoid cases has come from the steamship *Acme*, a vessel carrying lumber from Humboldt Bay, usually from Arcata, to San Francisco Bay and sometimes to San Pedro, the port of Los Angeles. This observation was reported to the State Board of Health and the Health Department of San Francisco. An investigation, carried on by the latter, brought to light evidence pointing to a member of the crew as a carrier. This man, H. O., was investigated during two weeks in the City and County Hospital in San Francisco, but was discharged on Dec. 15, 1911, after the city bacteriologist had reported that the blood gave negative Widal tests and that typhoid bacilli could not at that time be demonstrated in the stools.

The investigation by the city showed that the solution of this problem involved work in other cities. The State Board of Health was notified of this fact and immediately assigned the investigation to the Division of Epidemiology of the Bureau of the Hygienic Laboratory. The director of the bureau began work on the problem on Dec. 28, 1911.

The *Acme* takes fuel oil in San Francisco but discharges cargo in Oakland. No passengers are carried, and there are usually only twenty-one men employed on board. These are the captain, first mate, second mate, chief engineer, assistant engineer, two firemen, one cook, one waiter, and twelve seamen.

Sanitary surveys showed that the ship was on the whole no less sanitary than most vessels of her kind. There was evidence of recent alterations made by the owners in their attempt to check the series of typhoid cases by making the vessel more hygienic. The messroom for the officers was clean and attractive. The crew took the food which was set out for them and ate it sitting on the cargo. The galley was not so clean as is desirable. Dishes were washed in hot water in a small tank heated by steam coils.

The forecastle housed twelve men in very close quarters. There were three tiers of bunks and very little unoccupied space. The air conditions had recently been rendered less objectionable by the placing of a ventilator through the deck overhead. At the first inspection the sailors' water-closet was in a filthy state and suggested opportunity for the spread of infection by flies. Before the investigation had terminated conditions had been greatly improved by the replacing of the bowl, the installation of a system of constant flushing with seawater, and the cementing of the floor. The danger of conveyance of infection by flies was very slight while the ship was at sea and practically free from them, but considerable when the vessel was tied at fly-infested wharves.

The introduction of typhoid bacilli to the ship in the food-supply could be almost entirely ruled out. No fresh milk was taken aboard, condensed milk being used. Fresh vegetables, such as lettuce, radishes, celery, and onions, were eaten raw by the crew, but all the food except meat was purchased exclusively in San Francisco. Other ships buying in the same market were free from typhoid.

The drinking-water supply for the galley was taken through a pipe and faucet from a large closed iron tank. Near the forecastle was a new covered barrel from which the crew obtained water through a faucet for drinking and washing. Near the deck-house was an old cask which had escaped destruction at the time the alterations were made, when the other water-containers were replaced. It lay on its side, and water was obtained from it by dipping through a small square hole with a common drinking-cup. It is apparent that members of the crew reaching into the dark barrel would wet their hands and contaminate the water. This cask was called the officers' cask. It supplied water for the officers' table and for any members of the crew who found it convenient to drink from it. The officers' cask has recently been thrown overboard and has been succeeded by a small barrel with a faucet.

Samples were taken from each water-supply and were examined for colon bacilli. All the examinations were negative except one of two tests made of samples taken from the officers' cask. A portion of this one sample of water showing colon bacilli was incubated in lactose bile and later plated on Endo medium, but typhoid bacilli could not be demonstrated. Possibly the results would have been different if the officers' cask had not been freshly filled shortly before each examination.

In order to eliminate as far as possible infection from unknown water-supplies the owners had specified for some time past that all the drinking-water should be taken aboard in San Francisco. This meant that the officers' cask might receive contamination for nearly a week between fillings. Limiting the water-supply to a single safe source did not prevent further cases from developing.

It was evident that there were several methods by which typhoid bacilli might be readily distributed by one member of the crew to the others. The infection could be spread by contamination of the food during preparation, by pollution of the officers' cask, by soiling of the hands of the crew in the crowded forecastle or the insanitary toilet, or by transference of infectious material by flies from the toilet to the food-supply. The contamination of the officers' cask seemed to explain most satisfactorily the possible distribution of typhoid bacilli from a carrier to the majority of the cases.

Inquiry showed that the men did not frequent any particular boarding-house or saloon in Arcata or San Francisco. They ate on board ship during their term of service and most of them had never gone ashore in Arcata. In San Francisco they scattered about town as did the sailors from the other ships and they had no special rendezvous. Other ships than the *Acme* coming into San Francisco are comparatively free from typhoid.

In order to find out whether any other ships sailing to and from Humboldt Bay and taking water there were troubled with typhoid, a number of ships accessible in San Francisco Bay were visited and the owners of other vessels were interviewed. In no instance had

there been recent cases of typhoid fever on board the ships. On six ships sailing to Humboldt Bay we asked whether the men knew of any vessels on which there had been typhoid, and on four of the six the reply was made that the *Acme* had had trouble with the disease. No other ships were mentioned as having typhoid. Dr. S. B. Foster, the officer representing the United States Public Health and Marine-Hospital Service at Eureka, reported that no cases of typhoid had come under his care since January, 1908.

The evidence already presented gave ground for a strong suspicion that the series of typhoid cases among the crew of the *Acme* arose from a focus on board the ship. Every effort was then made to detect the source by examination of individuals who might be carriers. It was impossible to lay the blame on any one cook or waiter as these men had been changed at short intervals during the series of cases. A similar situation existed with regard to the seamen and firemen. With the exception of the captain (G. O.), the first mate (J. H.), the chief engineer (L. P.), and the winch-driver (H. O.). no members of the ship's company at the time of beginning the investigation had been aboard for any considerable period. When the first visit to the *Acme* was made, she was in dry-dock and all the men had been discharged except the four mentioned above. Of these only the captain (G. O.) and the winch-driver (H. O.) had been aboard during the entire series of cases. The captain had never had typhoid. The winch-driver had had the disease four years before, but he had been examined in December, 1911, by the city bacteriologist of San Francisco and his stools had been found free from typhoid bacilli. The first mate had not had typhoid. He had been aboard for a year, and two years previously he had been in service on the same ship. The chief engineer had been on the *Acme* since April 6, 1910, and had been infected with typhoid on the ship in February, 1911.

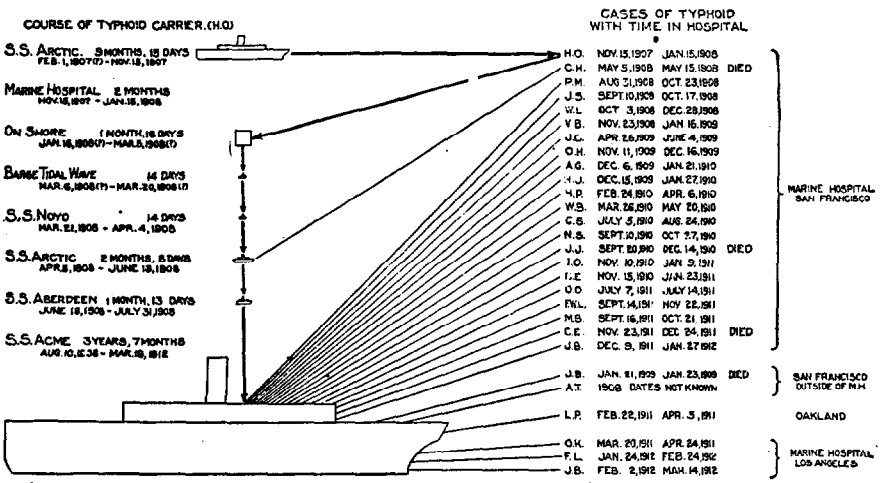

Chart showing periods of service of a typhoid carrier on six ships and resulting cases among the crews; prepared by Dr. W. A. Sawyer, director of the California State Hygienic Laboratory. Copyright, 1912, by California State Board of Health. Lengths of ships are proportional to length of stay of carrier on board ships.

The first laboratory investigation consisted of examinations of blood, feces and urine from the captain (G. O.), the first mate (J. H.), and the chief engineer (L. P.). Specimens were taken at the ship on December 30, and January 3, and additional samples from L. P. on January 16. Examination of the blood showed a positive Widal reaction for the engineer (L. P.). The other blood examinations were negative. Examinations of the urine and feces of each of the three men failed to reveal typhoid bacilli.

Shortly after the specimens from the captain, first mate, and chief engineer had been found to be free from typhoid bacilli, it was learned that two seamen of the *Acme* had just come down with typhoid and were under the care of the United States Marine Hospital in Los Angeles. It was decided to begin the investigation anew by making a thorough investigation of hospital records and of the names and dates on back pay-rolls of ship-owners, and also by interviewing as many of the early patients of the typhoid series from the *Acme* as could be reached. The records of the United States Marine Hospitals in San Francisco and Los Angeles were of great value, and we are greatly indebted to Surgeons James M. Gassaway and S. D. Brooks for placing hospital records at our disposal. We were fortunate in being able to find and interview four of the early patients, V. B., I. O., L. P., and O. K. The results of the searching of records and interviewing of former patients enabled us to secure the information shown on the chart illustrating this article. All the evidence tended to indicate that the winch-driver (H. O.) was responsible for the series of cases on the *Acme* and also for the single case received by the Marine Hospital since January, 1908, from the steamer *Arctic*. For the sake of brevity and clearness the chart has been made to show the history of H. O., the winch-driver, from the time of his taking service on the steamer *Arctic* to the time when our investigation was completed. The chart shows also the length of his stay aboard each ship on which he served, and indicates by initials all typhoid patients known to have come from these ships into hospitals and gives the dates of their stay under treatment. A study of the dates shows that all the cases received their infection while on board ship with H. O. The diagram shows also that patients from the *Acme* were cared for in three cities, San Francisco, Oakland and Los Angeles. That there were other undiscovered cases can be little doubted. In fact, one victim, J. F., who was reported by one of the crew, was omitted from the statistics because the diagnosis could not be confirmed by other evidence. The cases were not limited to the seamen. L. P. was chief engineer, and J. B., who died in the German Hospital in San Francisco, was first mate.

It will be noticed that during the stay of H. O. on the *Acme*, covering a period of forty-three months, there were twenty-six cases. During his period of service next in length (two and one-fourth months on the *Arctic*) one case occurred. In all there were twenty-seven cases of typhoid fever, four of which were fatal. Of the patients twenty-one were in the United States Marine Hospital in San Francisco, and three of them died, making the mortality 14.3 per cent. During the period beginning with H. O.'s return to work after his illness and ending Feb. 22, 1912, sixty-three typhoid patients were admitted into the Marine Hospital in San Francisco from all other ships entering San Francisco Bay, including the river boats, foreign ships and government boats. Of these sixty-three patients six died, showing a mortality

of 9.5 per cent. The cases traceable to the carrier, H. O., were one-fourth of all the typhoid cases admitted and were responsible for one-third of the resulting deaths. Under the care of the Marine Hospital in Los Angeles during the same period there were three cases from the *Acme* and fourteen cases from other ships. All of the seventeen patients recovered. All the cases which could be collected and confirmed showed that there had been twenty-seven cases traceable to H. O. and that four of the patients had died. This gives a mortality of 14.8 per cent., which suggests that the infection being distributed by H. O. was more virulent than the average strain of typhoid.

The evidence collected strengthened all previous suspicions that the infections came from a carrier on board the *Acme*, and special suspicion fell on H. O. It was decided to make thorough laboratory examination of

TABLE 1.—AGGLUTINATION TESTS ON THREE SUSPECTS AND TWO CONTROLS

Dilution of Serum Tested	Serum of				Serum of Control	
	G. O.	H. O.	L. P. vs. Hopkins	L. P. vs. H. O. 7th Gen.	A	B
1-4	+	+	+	±	±	+
1-8	±	+	+	±	±	+
1-10	±	+	+	±	±	+
1-20	—	+	±	+	±	+
1-40	—	+	—	+	—	—
1-80	—	+	—	+	—	—
1-100	—	±	—	+	· ·	—
1-160	—	±	—	+	—	—
1-200	—	—	—	+	—	—
1-300	—	—	—	±	—	—
1-400	—	—	—	—	—	—
1-800	—	—	—	—	—	—

TABLE 2.—RESULTS OF CULTURE EXAMINATION

Name	Spec.	No. of Endo Plates	Colonies Suspicious in 48 Hours	Colonies on Russell's Med.	Reaction on Russell's Med. After 2 to 14 Days	
					Positive	Negative
G. O.	Urine	6	None	0	0	0
G. O.	Feces	12	Few	14	0	14
G. O.	Feces	11	Few	25	0	25
H. O.	Urine	6	Few	5	0	5
H. O.	Urine	6	Few	5	0	5
H. O.	Feces	12	Very many	107	55	52
L. P.	Urine	6	Very few	20	0	20
L. P.	Feces	18	Very few	10	0	10
L. P.	Feces	6	Very few	5	0	5
L. P.	Feces	6	Very few	5	0	5

material from all persons under slightest suspicion and to begin with the chief engineer. (L. P.), the captain (G. O.), and the winch-driver (H. O.). The plan included keeping each man under investigation in a hospital for at least twenty-four hours. This would insure that the specimens were *bona fide* and properly taken. The A. W. Beadle Co., owners of the *Acme*, generously met the expense of keeping the men in the Roosevelt Hospital in Berkeley. On March 2, the *Acme* came into port at Oakland and the captain (G. O.) and winch-driver (H. O.) came to the hospital. Specimens of blood, urine, and feces were obtained from the two men during their stay of thirty hours. On March 10 the chief engineer (L. P.) reported for observation. Similar specimens were obtained from him during the following twenty-four hours. All three of the men were given fluidextract of cascara on admission to the hospital and Epsom salts the next morning.

The results of agglutination tests performed on the blood samples from G. O., H. O., L. P., and two normal individuals who had never had typhoid fever (A. and B.) are given in the first table. The test was made macroscopically and the serum was allowed to act for twenty-four hours in the specified dilutions on bouillon cultures of the Hopkins strain of typhoid except in one of the tests of the serum of L. P. In that case the sixth generation of a typhoid culture isolated from the stool of H. O. was used. It will be noticed that the serum of L. P. who had been infected on board the *Acme* had much greater agglutinating power for the bacilli from H. O. than for the standard laboratory culture. In Table 1 positive results are indicated by the sign +, negative by the sign — and partial (showing clumps and cloudy fluid) by the sign ±.

The specimens of feces and urine were plated on Endo medium. Suspicious colonies were transferred to Russell's double sugar agar. Those showing reactions characteristic of typhoid bacilli were submitted in bouillon culture to macroscopic agglutination tests with antityphoid serum. The results of the first part of these examinations are shown in Table 2.

In the second table it will be seen that fifty-five of the cultures isolated from the feces of H. O. gave the reaction characteristic of typhoid bacilli on Russell's medium. Twenty-six of these were planted on broth, and this third generation of the organisms on artificial mediums was tested with antityphoid serum. The macroscopic agglutination test was positive in twenty-four hours in all cases in dilutions of one to twenty but only partial in dilutions of one to fifty. In glucose broth these cultures all produced acid but no gas. Seven of these cultures from H. O., together with controls of known typhoid and colon bacilli, were tested for motility, for indol production, for acid and gas formation in various sugar media (dextrose, lactose, mannit), for production of color-change in neutral red agar, for coagulation of milk, and for liquefaction of gelatin. The cultural characteristics of the seven organisms from H. O. were identical with those of the typhoid bacillus. The failure to be completely agglutinated by antityphoid serum in dilution of one to fifty was accredited to the power which newly isolated cultures have of resisting agglutinins. This explanation was confirmed after some of the cultures had been transplanted through the eleventh generation in the course of two weeks. The strains from H. O. then equaled the Hopkins strain in agglutinability. Both strains gave complete agglutination at one to 4,000 and partial results up to one to 500,000. One of the H. O. cultures even showed evidence of clumping at one to 1,000,000.

The proof that H. O. was a carrier was now considered complete and the findings were reported to the secretary of the State Board of Health for executive action. What to do with H. O., now that he was known to be a constant source of danger, became a serious problem. He was an able-bodied man of 36. He had not been sick since recovering from typhoid in January, 1908, and he complained of no symptoms. He ran the winch on the forward end of the *Acme* and cared for the lamps and gears when the ship was at sea.

At a conference between health officials and a representative of the owners of the *Acme*, it was decided, on March 19, 1912, that this carrier should be taken off the *Acme* and an attempt should be made to rid him of his infection through appropriate treatment. Surgeon James M. Gassaway made this possible by offering to

take him into the United States Marine Hospital in San Francisco for study and treatment. Accordingly the Secretary of the State Board of Health visited the *Acme* and notified H. O. that he would be transferred to the Marine Hospital and would be placed under quarantine there. When H. O. was informed of the danger of his presence to others, he showed deep concern and voluntarily gave up his work and entered the hospital.

A consideration of the facts revealed by the investigation of the source of typhoid fever on the *Acme* leads to the following observations:

1. A carrier may be of great danger to others, even when not occupied in the preparation or handling of food. Conditions on shipboard may be specially favorable to the transference of infection, as witnessed by the occurrence of twenty-six cases within three and a half years on a ship carrying twenty-one men.

2. In examinations of cultures freshly isolated from materials suspected of containing typhoid bacilli, negative agglutination tests with the usual dilutions of serum should not be accepted without cultural confirmation. The well-known power of freshly isolated cultures to resist agglutinins was strikingly illustrated.

3. Emphasis is given by this investigation to the point which others have made that typhoid patients should not be unconditionally dismissed by physicians unless their feces and urine have been examined and found to be free from typhoid bacilli. If the staff of the Marine Hospital in San Francisco had discovered typhoid bacilli in the stools of their patient, H. O., in January, 1908, and had in some way prevented his spreading typhoid among sailors, this one hospital would have saved for itself the expense of treating twenty-one typhoid patients, and four deaths would have been prevented.